Reliability of Materials

ENRE 447
Co Listed With ENMA 426

Course Syllabus

Course Objectives:
Advanced failure mechanisms in reliability engineering will be taught from a basic materials and defects point of view. The methods of predicting the physics of failure of devices, materials, components and systems are reviewed. The main emphasis will be given to basic degradation mechanisms through understanding the physics, chemistry, and mechanics of such mechanisms. Mechanical failures are introduced through understanding fatigue, creep and yielding in materials, devices and components. The principles of cumulative damage and mechanical yielding theory are taught. The concepts of reliability growth, accelerated life testing, environmental testing are introduced.

Physical, chemical and thermal related failures are introduced through a basic understanding of degradation mechanisms such as diffusion, electromigration, defects and defect migration. The failure mechanisms in basic material types will be taught. Failure mechanisms observed in real electronic devices and electronic packaging will also be presented. Problems related to manufacturing, and microelectronics will be analyzed. Mechanical failures are emphasized from the point of view of complex fatigue theory.

Course Instructor: Professor Aris Christou
Office Hours: Thursday 2:00-3:00 PM, CHE-NUC 2309

Course Texts: "Reliability Physics and Engineering" by J.W. McPherson, Published by Springer. ISBN 978-1-4419-6347 (2010).
Also (not required) : " Practical Reliability Engineering" by Patrick O'Conner, published by Wiley, Fourth

References:

1. "Reliability and Quality in Microelectronic Die Manufacturing" by Aris Christou and Willie M. Webb,
   Published by Reliability Information Analysis Center, 2006.
   ISBN-10 1-933904-15-1 (reference).
2. "Failure Mechanisms in Semiconductor Devices", Second Edition by A. A. Amerasekera and F. N. Najm, published by Wiley.
3. "Failure of Materials in Mechanical Design" Jack A. Collins, second edition, 1993, publioshed by Wiley.

Course Notes in Failure mechanisms are provided by the instructor to supplement the required text books.

Course Notes and Assignments: Posted on www.blackboard.com. All solutions as well as the the power point presentation of each lecture is presented.

Grading: Homework Assignments: 10%
Homework Assignments are due the following week after assigned.
No late homework!
Mid Term: 30% and Final Exam: 30 %. Project: 30%

Course Outline

- ***Reliability Introduction***: Definitions, Dimensions, Objectives, Case Studies. The objectives of the course are presented, The overview of reliability engineering as a discipline is discussed. Also covered are concepts of reliability of complex systems, system failure analysis, fault tree analysis, event tree construction and simulation modeling. (two weeks)

- ***Failure Mechanisms and Reliability Mathematics:*** The key mathematical concepts in understanding the probabilistic aspect of failure mechanisms will be reviewed. Main distribution functions and failure rates will be presented. It is assumed that the student has or will take other courses emphasizing Reliability Math. Applications to failure mode analysis are presented, failure mode and effects analysis, and statistical quality control. Rules of Boolean Algebra and application of distribution tables are taught. (four weeks)

- ***Materials Properties***: Defects in Materials, properties of materials, Mechanics of materials are presented. Basic properties of materials and their classification are presented, as applied to stress overload conditions. (one week)

- ***Defect Isolation***: Failure Analysis Methodology, mechanical and physical failure analysis techniques. We will emphasize microscopy techniques including acoustic microscopy. Part of the lecture will be a video presentation for failure analysis (one week).

- ***Failure Mechanisms***: Discussion of mainly mechanical failure mechanisms related to fatigue. Finite element fatigue analysis techniques are taught. Fatigue in complex loading environments is introduced. The concepts of fracture mechanics are introduced through a series of applications with emphasis on probabilistic fracture mechanics. (two weeks)

- ***Failure Mechanisms***: Discussion of electrical and physical failure mechanisms, defect isolation at the microelectronic die and electronic packaging. Discussion of physical failure mechanisms such as diffusion related metal migration, corrosion and oxidation. (two weeks)

- ***Failure Mechanisms in Complex System and Materials Selection for Reliable Designs***: Load interference, load –strength probabilistic concepts are applied to complex material systems with complex phases and microstructure. (two weeks)

- ***Class Presentation of Projects***: Each student will carry out a complex failure mechanism determination and modeling study. Class presentations will be given with an opportunity for peer feed back and improvement. (one day)

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